MAP MF-1853-C

MISCELLANEOUS FIELD STUDIES

**VOLCANOGENIC MASSIVE-SULFIDE MAP SERIES** 

Cox, D.P., and Singer, D.A., eds., 1986, Mineral deposit models U.S. Geological Survey Bulletin 1693, 379 p. Degenhart, C.E., Griffith, R.J., McOuat, J.F., and Bigelow, C.G., 1978, Mineral studies of the western Brooks Range--U.S. Bureau of Mines: U.S. Bureau of Mines Open-File Report 103-Dillon, J.T., Moorman, M.A., and Lueck, Larry, 1981, Geochemical reconnaissance of the southwest Wiseman quadrangle: summary of data on rock samples: Alaska Division of Geological and Geophysical Surveys Open-File report 133B, 164 p, 1 sheet, Drechsler, J.S., Jr., and Dunbier, J., 1981. The Greens Creek ore Metallurgical Bulletin, v. 76, no. 833, p. 57. Dunbier, John, Snow, G.G., and Butler, T.A., 1979, The Greens Creek project, Admiralty Island, Alaska [abs.], in Alaska's mineral and energy resources, economics and land status; northern Alaska -- Introduction: Economic Geology, v. 81, p. 1583-1591 I.L., 1982, The Story Creek and Whoopee Creek lead-zinc ed., The United States Geological Survey in Alaska --

844. p. 35-38. deposit (table 1) consists of disseminated to massive chalcopyrite Folger, P.F., and Schmidt, J.M., 1986, Geology of the carbonatehosted Omar copper prospect, Baird Mountains, Alaska: Economic Geology, v. 81, p. 1690-1695. deposit and the surrounding mineral district, Delong Mountains, western Brooks Range, Alaska: Minneapolis University of Minnesota, Ph.D. dissertation, 161 p. deposit, western Brooks Range, Alaska [abs.]--SEDEX [abs.]: Geological Society of America Abstracts with Programs, v. 16, p. 511.

of the Brooks Range allochthon (Mayfield and others, 1983) and is part of the Endicott Mountains subterrane (map). The Baird Group, which hosts the Frost deposit, forms part of the Kelly River allochthon (Mayfield and others, 1983) and is part of the DeLong Mountains subterrane (map). An extensive belt of major Kuroko massive-sulfide deposits west trend for about 260 km along the southern flank of the Brooks Range (map, table 1). The largest deposits are in the Ambler district (Hitzman and others, 1982): the Arctic, which contains an estimated 32 million tonnes of ore (Schmidt, 1983, 1986), and the Ruby Creek, which contains an estimated 91 million tonnes of ore averaging 1.2 percent Cu (Hitzman, 1986) (table 1). Other Kuroko massive-sulfide deposits in the belt are the Smucker, BT. Jerri Creek, Roosevelt Creek, Sun, and Michigan Creek deposits (map, table 1) (Hitzman and others, 1982). The Ann deposit in the southern Brooks Range may be either a polymetallic vein or a metamorphosed sulfide deposit (table 1). The Kuroko massive-sulfide deposits in the Ambler district are in or adjacent to submarine mafic and felsic metavolcanic rocks and associated carbonate, pelitic, and graphitic metasedimentary rocks of the Devonian and Mississippian Ambler sequence (Hitzman and others, 1982). The Ambler sequence, along and Anirak Schist, forms the informally named "schist belt" of the southern Brooks Range (Hitzman and others, 1982). The Ambler sequence is generally multiply deformed and exhibits metamorphism of both greenschist and blueschist facies (Hitzman and others, 1982). The deposits are in the Ambler sequence, which forms the southern part of the Hammond subterrane (map). Most workers in the southern Brooks range favor an origin within a continental-margin rift rather than in an island-arc for these Kuroko massive-sulfide deposits. The Ruby Creek deposit, classified as a Kipushi copperlead-zinc deposit, is genetically related to Devonian submarine volcanism (Hitzman, 1986). Bernstein and Cox (1986) stress the

SEWARD PENINSULA

Briskey, written commun., 1985).

Lange, 1985). This assemblage is interpreted as the upper structural and stratigraphic level of the Yukon-Tanana terrane (Nokleberg and Aleinikoff, 1985; Nokleberg and others, 1986). and Middle Devonian to Lower Mississippian Totatlanika Schist (Wahrhaftig, 1968; Gilbert and Bundtzen, 1979). The Kuroko Devonian submarine volcanism (Nokleberg and others, 1987, 1988) SOUTHERN ALASKA the southwest and Denali to the east (map, table 1). The

The southern Alaska Range, in southern Alaska, contains two significant Besshi massive-sulfide deposits, Shellabarger Pass to Shellabarger Pass deposit consists of a very fine grained mixture chalcopyrite, galena, and pyrrhotite in carbonate-rich beds and as fracture fillings in Triassic or Jurassic chert and siltstone and associated pillow basalt (Reed and Eberlein, 1972). The Denali deposit consists of stratiform bodies of very fine grained and thin-layered chalcopyrite and minor pyrite in thin-bedded, shale rich calcareous argillite enclosed in the Upper Triassic Nikolai Greenstone (Stevens, 1971; Seraphim, 1975). In the eastern Chugach Mountains, Besshi and Cyprus massivesulfide deposits in the Prince William Sound district along the eastern and northern margins of the Gulf of Alaska are Beatson, Copper Bullion, Ellamar, Fidalgo-Alaska, Knight Island, Latouche, Midas, Pandora, Schlosser, Standard Copper, and Threeman (map, table 1). Midas, the northernmost deposit, is in the southern part of the Valdez Group, which in this area consists of metamorphosed and deformed Upper Cretaceous flysch and greenstone derived from basalt. The other deposits to the south are in the Orca Group. Most of the deposits are classified as sediment-hosted Besshi massive-sulfide deposits; Knight Island, Standard Copper, and breeman are basalt-hosted deposits classified as Cyprus massive sulfide deposits (table 1). The Orca Group, which hosts most of the deposits, consists of a strongly deformed, thick assemblage of Paleocene and Eocene graywacke, argillite, minor conglomerate, pillow basalt, basaltic tuff, sills, and dikes (Winkler and

Plafker, 1981), part of the Prince William terrane (map). SOUTHEASTERN ALASKA this report, southeastern Alaska is divided into three north-Coast Mountains region consists of the informally named Coast approximately equivalent, from east to west, to part of the to part of the Gravina-Nutzotin belt (Monger and Berg, 1987). and others, 1984), which is approximately equivalent to the terrane (Monger and Berg, 1987). The mineral occurrences, deposits, and mines within this complex geologic region are likewise a complex, including a 1981; Berg, 1984). The Coast Mountains region contains an massive-sulfide deposit. Central southeastern Alaska contains

contains no known significant volcanogenic massive-sulfide or related lode deposits. Coast Mountains Region the Midas, Latouche, Beatson, Ellamar, and Fidalgo-Alaska mines in strike length of about 300 km. The deposits consist of

Cyprus Massive-Sulfide Deposit (D.A. Singer in Cox and Singer, 1986)

Sedimentary Exhalative Zinc-Lead Deposit (J.A. Briskey <u>in</u> Cox and Singer, 1986) This deposit type consists of stratiform, massive to

Kipushi Copper-Lead-Zinc (Carbonate-Hosted Copper) Deposit (D.P. Cox and L.R. Bernstein in Cox and Singer, 1986) This deposit type consists of stratabound, massive sulfide and tennantite, and minor renierite and germanite. Local dolomite, combined Cu and Zn and as much as 45 percent BaSO4. The Khayyam Kuroko massive-sulfide deposits such as those nearby to the north

This deposit type consists of stratabound, massive to plutonic-metamorphic complex of Brew and Ford (1984a, b) or in the Alexander belt. Notable examples of metamorphosed sulfide deposits are the Sweetheart Ridge, Sumdum, Groundhog Basin, and Moth Bay deposits, all in southeastern Alaska.

This deposit type consists of stratiform, massive barite basins or embayments, or submerged volcanic arcs, and associated smaller local basins. Many bedded-barite deposits are associated with sedimentary exhalative zinc-lead or Kuroko massive-sulfide local, weak to moderate sericite replacement. Associated minerals include minor witherite, pyrite, galena, and sphalerite. Notable examples of bedded-barite deposits in Alaska are the Nimiuktuk

ABBREVIATIONS AND CONVERSION FACTORS USED IN THIS REPORT The following abbreviations and symbols are used. Standard PGE: Platinum-group elements--minerals and alloys

REE: Rare-earth elements

The following conversion factors were used to convert weight

g, kg, t: gram, kilogram, tonne g/t, g/m<sup>3</sup>: grams per metric ton, grams per cubic meter tonne: metric ton %: percent

and volume from U.S. Customary to metric quantities: 1 cubic yard = 0.765 cubic meter 1 troy ounce per short ton = 34.29 grams per metric ton 1 part per million = 1 gram per metric ton

1 pound = 0.454 kilogram 1 troy ounce = 31.10 grams 1 short ton = 0.907 metric ton

1 flask (76.0 pounds mercury) = 34.7 kilograms AND RELATED LODE DEPOSITS OF ALASKA

SUMMARY OF VOLCANOGENIC MASSIVE-SULFIDE BROOKS RANGE

The northwestern Brooks Range contains several sedimentary

basin (Nokleberg and others, 1987, 1988). The eastern part of the northwestern Brooks Range contains a belt of sulfide-vein deposits: Story Creek, Whoopee Creek, Frost, and Omar (map, table 1). These sulfide-vein deposits are summarized in this report because they may be, in part, remobilized from volcanogenic massive-sulfide deposits. The sulfide-vein deposits generally consist of sphalerite and galena,

northwest-trending regions: the Coast Mountains region, central southeastern Alaska, and coastal southeastern Alaska (map). The Stikinia terrane, to all of the Tracy Arm and Taku terranes, and Central southeastern Alaska consists of the Alexander belt (Brew Alexander terrane (Monger and Berg, 1987). Coastal southeastern Alaska consists of the Kelp Bay Group and similar unnamed rocks. both part of the Wrangellia terrane (Monger and Berg, 1987), and extensive suite of metamorphosed sulfide deposits and one Besshi extensive suites of Kuroko massive sulfide, bedded barite, and metamorphosed sulfide deposits. Coastal southeastern Alaska

region are Sweetheart Ridge, Sumdum, Groundhog Basin, Alamo, Mahoney, Moth Bay, Reliance, and Red River (map, table 1). The metamorphosed sulfide deposits are widespread and occur along a stratabound, massive to disseminated sulfide minerals hosted by moderately to highly metamorphosed and deformed volcanic and sedimentary rocks. Original or primary features of the deposits have been so obscured by metamorphism and deformation as to as indicated by high lead and silver concentrations, and the presence of metamorphosed felsic volcanic rocks. All but one of the deposits are in the western metamorphic zone of the informally named Coast plutonic-metamorphic complex of Brew and Ford (1984a. b), west of the foliated tonalite sill, in the Taku Coast plutonic-metamorphic complex in the Tracy Arm terrane in these deposits. The Groundhog Basin deposit contains an estimated several hundred thousand tonnes grading 8 percent Zn.

estimated 91,000 tonnes grading 7.5 percent Zn and 1 percent Cu and 0.75 percent Cu.

Central Southeastern Alaska The major significant volcanogenic massive-sulfide and related lode deposits in central southeastern Alaska are (1) the Kuroko massive-sulfide deposits of Glacier Creek, Orange Point, Greens Creek, Pyrola, Kupreanof Island, Helen S., Zarembo Island, Khayyam, Niblack, Barrier Islands, and Driest Point; (2) the metamorphosed sulfide deposits of Cornwallis, Copper City, and Lime Point (map, table 1). Some of the bedded-barite deposits. such as Castle Island, may be related to Kuroko massive-sulfide principally by Paleozoic and early Mesozoic metasedimentary, metavolcanic, and metaplutonic rocks of the Alexander belt (Brew and others, 1984), which is approximately equivalent to the

Alexander terrane. This unit consists mainly of Ordovician or older(?) carbonate rocks, carbonaceous flysch, chert, terrigenous and marine clastic rocks; Ordovician to Triassic metamorphosed basaltic to silicic flows and related volcaniclastic rocks: and Ordovician and Silurian diorite and trondhjemite. Younger plutonic rocks in the Alexander belt consist of Jurassic granite, Cretaceous granodiorite, Mesozoic (mainly Cretaceous) pyroxenite, gabbro-norite, and gabbro, and Tertiary granite, granite porphyry, and felsic dikes. Substantial amounts of copper, lead, zinc, barium, silver, and gold occur in, or have been produced from, the Kuroko massivesulfide deposits and bedded barite in central southeastern Alaska (Nokleberg and others, 1987). The Glacier Creek deposit contains an estimated minimum 680,000 tonnes grading as much as 3 percent deposit produced about 6.4 million kg Cu, 40,120 g Au, and 53,200 g Ag from 205,000 tonnes of ore. The Niblack deposit produced about 636,000 kg Cu, 34,200 g Au, and 466,500 g Ag. The Greens Creek deposit. which is scheduled to begin production in 1988 contains an estimated 3.6 million tonnes grading 0.4 percent Cu 2.7 percent Pb, 8.0 percent Zn, 360 g/t Ag, and 3.4 g/t Au (table 1). These Kuroko massive-sulfide deposits in central southeastern Alaska extend more than 300 km along the strike length of the Alexander belt. Cornwallis, Copper City, and Moonshine in central southeastern Alaska are metamorphosed sulfide deposits in carbonate and metavolcanic host rocks. The Copper City deposit produced about 1,450 tonnes of ore, and the Moonshine deposit produced about 46,500 g Ag (table 1); no model is available to

BaSO4. The Lime Point deposit contains an estimated 4,500 tonnes grading 91 percent barite. ACKNOWLEDGMENTS

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Barnes, D.F., 1978, Mineral resources of the Glacier Bay National Monument Wilderness Study Area, Alaska: U.S. Preliminary reconnaissance geologic map of the Petersburg and parts of the Port Alexander and Sumdum 1:250,000 quadrangles, southeastern Alaska: U.S. Geological Survey Open-File Report

METALLOGENIC MAP OF SIGNIFICANT VOLCANOGENIC MASSIVE-SULFIDE AND RELATED LODE DEPOSITS IN ALASKA Warren J. Nokleberg<sup>1</sup>, Thomas K. Bundtzen<sup>2</sup>, Henry C. Berg<sup>3</sup>, David A. Brew<sup>1</sup>,

Donald Grybeck<sup>1</sup>, Mark S. Robinson<sup>2</sup>, and Thomas E. Smith<sup>2</sup>

VOLCANOGENIC MASSIVE-SULFIDE MAP SERIES

Edited by R. L. Earhart <sup>1</sup> U.S. Geological Survey

<sup>2</sup>Alaska Division of Geological and Geophysical Surveys <sup>3</sup> 115 Malvern Avenue, Fullerton, CA 92632

1989

EXPLANATION Lode deposits -- Showing number keyed to table 1 Kuroko massive-sulfide deposit type Besshi massive-sulfide deposit type Bedded-barite deposit type ortheastern

Cyprus massive-sulfide deposit type Sedimentary exhalative zinc-lead deposit type Kipushi copper-lead-zinc (carbonate-hosted copper) ♦ 14 Metamorphosed-sulfide deposit type Unclassified sulfide-vein deposit type — — Boundary between geographic regions Contacts Terrane-bounding fault--Dashed where approximately located; dotted where concealed Postaccretion or postamalgamation contact--Includes both depositional contacts and faults that are not terrane boundaries SEWARD

Metamorphosed sulfide No data

or polymetallic vein(?).

schist. Hosted in Late Proterozoic(?) banded schist and paragneiss. Deposit is adjacent to

Late Proterozoic(?)

DESCRIPTION: Vein and stratabound massive galena and lesser sphalerite, bornite,

Roosevelt Creek. Kuroko massive sulfide. No data

Cu, Zn, Pb, Ag, Au Devonian metavolcanic

others, 1981; W.P. Brosge and J.T. Dillon, oral commun., 1986.

Grybeck, 1977; J.T. Dillon, oral commun., 1986.

Michigan Creek.

As, Au, Ag, Cu,

Dillon, oral commun., 1986.

metasedimentary rocks

chalcopyrite, and alteration malachite and azurite in marble, calc-schist, and pelitic

the granite pluton of Ernie Lake, along with nearby smaller occurrences around periphery

of pluton. Deposit may be polymetallic vein, or remobilized stratabound deposit. SOURCES:

DESCRIPTION: Disseminated(?) and massive sulfide minerals, probably mainly chalcopyrite

Devonian and Mississippian Ambler sequence. SOURCES: Grybeck, 1977; W.P. Brosge and J.T.

DESCRIPTION: Disseminated to massive chalcopyrite and argentiferous galena as much as 0.1

SEWARD PENINSULA

m thick in felsic schist and crosscutting pyrite veins. Hosted by felsic schist, marble,

and phyllite of the Devonian and Mississippian Ambler sequence. SOURCES: Dillon and

quartzite

DESCRIPTION: Blebs, stringers, massive boulders, and disseminations of galena, pyrite,

crudely banded micaceous quartzite enclosed in an isolated lens of marble. Marble

quartzite, marble, and quartz-mica-graphitic schist, all within or near exposures of

contained in early Paleozoic quartz-mica-graphite schist, part of mixed unit of Till

(1984). Deposit is highly oxidized; exposure is poor. Zones of blebs, stringers, and

is interpreted as metamorphosed laminated exhalite, possibly a sedimentary exhalative

sphalerite, and barite with gangue of quartz, calcite, and limonite in Paleozoic micaceous

isseminations appear conformable with bedding and banding in quartzite. Zones as much as

farther southeast are exidized stringer zones or lenses of pervasive limonite, quartz, and

chlorite that are cut by veins and stockworks of quartz and chlorite. Stringer zones and

EAST-CENTRAL ALASKA--NORTHERN ALASKA RANGE REGION

Kuroko massive sul-

Totatlanika Schist

DESCRIPTION: Fine-grained arsenopyrite, chalcopyrite, pyrrhotite, and bismuthite stringers

and laminations parallel to foliation. The sulfide zone reaches a maximum thickness of 10

m and is 200 m long. The laminations vary from a few centimeters to 1 m thick. Lenses and

California Creek Member of the Middle Devonian to Lower Mississippian Totatlanika Schist

but are locally folded. Quartz-tourmaline-sulfide veins from 10 cm to 1 m thick crosscut

sulfide minerals occur immediately adjacent to a metamorphosed porphyry interpreted as a

Paleozoic igneous plug that was contemporaneous with the volcanic rock protoliths of the

produced in 1930's. SOURCES: Hawley, 1976; E.R. Pilgram, written commun., 1976; Gilbert

fide. Precambrian or

Paleozoic Keevy Peak

DESCRIPTION: Fine-grained sphalerite, galena, and pyrite in massive lenses in siliceous

phyllite and metaconglomerate of the Precambrian or Paleozoic Keevy Peak Formation.

Sulfide zone extends along strike for 300 m and vertically for 200 m. Sulfide lenses

isoclinally folded and possibly associated with tuffaceous chlorite schist. SOURCE: T.K

Lower Mississippian

DESCRIPTION: Massive sulfide layers containing pyrite, chalcopyrite, galena, sphalerite,

enargite, and arsenopyrite in gangue of quartz, sericite, chlorite, calcite, barite, and

siderite. Hosted by metamorphosed marine tuffaceous rhyolite and metamorphosed calcareous

clastic rocks correlated with the Moose Creek Member of the Totatlanika Schist. Numerous

Domal sulfide accumulations at top of layers. Absence of footwall alteration and stringer

derived from schist basement. SOURCES: Gilbert and Bundtzen, 1979; C.J. Freeman, written

Middle Devonian to

Lower Mississippian

DESCRIPTION: Massive pyrite, sphalerite, galena, and chalcopyrite with quartz-rich gangue

in felsic metavolcanic rocks derived from crystal and lapilli tuff. minor flows, and in

metasedimentary rocks. Massive sulfide layers on both sides of large east-west trending

exhalite as much as 130 m thick hosts massive-sulfide layers. An older, southern horizon

Deposits occur immediately below the Sheep Creek Member and above the Mystic Creek Member

syncline. Proximal setting for Red Mountain deposit on south limb, where sulfide-silic

hosts sphalerite and coarse pyrite in black chlorite schist. Distal setting for WTF

DESCRIPTION: Zone of massive sulfide lenses, pods, and disseminations containing

quartz keratophyre flows and tuffs, and Devonian or older shale, marl, and marble.

pyrrhotite, chalcopyrite, sparse pyrite, and sphalerite. Zone about 13 km long and as much

minerals occur in interfoliated former marine sequence of quartz-mica, muscovite-chlorite

Metavolcanic and metasedimentary rocks part of Yukon Crystalline terrane. Two periods of

metamorphism and deformation, an older, lower amphibolite facies, and a younger lower

reenschist facies. Intensely deformed with locally abundant mylonite schist. SOURCES:

DESCRIPTION: Disseminated to massive pyrite, chalcopyrite, and sphalerite in two or three

layers exposed discontinuously in a zone as much as about 15 m thick and 2 km long.

biotite, and actinolite. Sulfide minerals occur in interfoliated marine sequence of

metasedimentary rocks, mainly quartz schist, chlorite-quartz schist and marble, and less

terrane. Two periods of metamorphism and deformation, an older lower amphibolite facies

and metasedimentary

DESCRIPTION: Large massive sulfide district of about 1,000 sq km, comprises about 26

stratiform, transposed, and lesser replacement deposits along four regional trends.

Deposits consist of varying amounts of pyrite, chalcopyrite, galena, sphalerite, and

and lead-silver-gold sulfide minerals. Massive sulfide minerals and adjacent layers

breccia, and metamorphosed shallow- and deep-marine sedimentary rocks, mainly quartz

metasedimentary rocks part of Yukon crystalline terrane. Abundant numerous tholeiitic

greenstone sills spatially related to massive-sulfide bodies, and possibly genetically

related to metavolcanic suite. SOURCES: Nauman and others, 1980; Lange and Nokleberg,

1984; C.R. Nauman and S.R. Newkirk, written commun., 1984; I.M. Lange and W.J. Nokleberg

SOUTHERN ALASKA

Besshi massive-sulfide deposits -- southwestern and central Alaska Range

sphalerite, chalcopyrite, galena, and pyrrhotite in a gangue of siderite, calcite, quartz

and dolomite. Sulfide minerals and gangue occur in lenticular massive-sulfide bodies, as

upper sequence of pillow basalt, agglomerate, and breccia. At least six individual sulfide

bodies. Highest chalcopyrite concentrations in basal parts of deposits. Minor sphalerite

replacements of carbonate-rich beds, and as fracture fillings, mainly in chert and

siltstone. Host rocks of Triassic and (or) Jurassic age consist of lower sequence of chert, dolomite, siltstone, shale, volcanic graywacke, conglomerate, aquagene tuff, and

in or near hanging-wall zones. Main sulfide bodies may be proximal to basaltic flow

High background copper values of 250 to 300 g/t. SOURCES: Reed and Eberlein, 1972;

DESCRIPTION: Stratiform masses and bodies of very fine grained and thin-layered

chalcopyrite and pyrite in thin-bedded, shaly, carbonaceous, and limy argillite enclose

in the Upper Triassic Nikolai Greenstone. Zone as much as 166 m long and 9 m wide. Zone

facies. Several hundred meters of underground workings. Mine developed from 1964 to 1969

Interpreted to have formed in reducing or euxinic marine basin created by abundant organic matter and sulfate reducing bacteria, in a submarine volcanic environment. SOURCES:

extends at least 212 m below surface. Rhythmic layering of sulfide minerals. Locally

moderately folded. Sulfide minerals and host rocks metamorphosed at lower greenschist

fronts. Extensive hydrothermal alteration in footwall; rare to absent in hanging wall

DESCRIPTION: Very fine grained mixture of mainly pyrite and marcasite and lesser

hellabarger Pass. Besshi massive sulfide. Estimated several hundred

Mesozoic pillow basalt thousand tonnes of unknown

average of 2% Cu, 1% Zn

and sedimentary rocks grade. As much as 5% Cu,

Besshi massive sul- Massive sulfide layers

fide(?). Upper Triassic containing abundant Cu

schist, quartz-chlorite-feldspar schist, calc-schist, and marble. Metavolcanic and

Associated hydrothermal alteration with formation of chlorite, quartz, sericite, pyrite,

contain disseminated sulfide minerals in zones typically 500 m long. 200 m wide, and 15 m

thick. Hosted by metamorphosed Devonian spilite and keratophyre suite of flows, tuffs, and

lesser malachite and bornite. Gangue of mainly quartz, carbonate, and white mica.

and a younger lower greenschist facies. Intensely deformed, mylonite schist locally

abundant. SOURCES: Lange and Nokleberg, 1984; Nokleberg and Lange, 1985.

amounts of metamorphosed Devonian andesite, dacite, and keratophyre flows, tuff, and

Individual massive pods as much as 1 m thick. Gangue of quartz, chlorite, epidote

McGinnis Glacier. Kuroko massive sulfide. Grab samples contained as

Zn, Cu, Po, Ag Devonian metavolcanic much as 2.3% Zn, 0.26% Cu,

Delta District. Kuroko massive sulfide. Largest deposit of 18 million

34-100 g/t Ag, 1-3.4

and metasedimentary 0.25% Pb, 50 g/t Ag

quartz, quartz-feldspar augen schist, chlorite schist, calc-schist, and marble. Host rocks

derived from Devonian felsic to intermediate volcanic rocks, mainly andesite, dacite, and

as 0.5 km wide. Individual lenses and pods as much as 5 m long and 1 m thick. Sulfide

of the Totatlanika Schist. SOURCE: D.R. Gaard, written commun., 1984

deposit on north limb, which contains a thin blanket of fine-grained sulfide minerals

Totatlanika Schist

mineralization suggests off-vent deposition. High trace values of As, Sb, Hg, and W may be

WTF, Red Mountain. Kuroko massive sulfide. Estimated 1.10 million tonnes

high-angle faults. Sulfide beds appear to overlie irregular paleosurface in footwall.

Totatlanika Schist

Anderson Mountain. Kuroko massive sulfide. Grades from 0.5 to 19% Cu,

sulfide zones and adjacent schist. The wallrock is locally symmetrically altered. The

Totatlanika Schist, Quartz veins may represent either remobilized stratiform sulfide

minerals or polymetallic veins associated with nearby Tertiary(?) mafic dikes. Gold

and Bundtzen. 1979: Bundtzen and Gilbert, 1983; T.K. Bundtzen, written commun., 1985.

Zn, Pb, Sn, Ag

commun., 1984; T.K. Bundtzen, written commun., 1984

Lange and Nokleberg, 1984; Nokleberg and Lange, 1985.

Cu, Pb, Zn, Ag,

Bundtzen, written commun., 1985.

aminations parallel foliation in enclosing siliceous metavolcanic phyllite of the

Mississippian

90 m wide and extend for about 2 km along northwest-southeast trend. On strike about 2 km

Kuroko massive sulfide. Grab samples contained as much

Metamorphosed sulfide. As much as 10% Pb, 2.2% Zn, 1.4

Estimated 91,000 tonnes

Kuroko massive sul- Grab samples contained as much

Middle Devonian to as much as 5% Pb, 28% Zn, and

171 g/t Ag

grading 34.3 g/t Au, 10% As

as 15% combined Pb and Zn. 102

grading 0.15% Cu, 2.5% Pb, 7.9% Zn, 270 g/t Ag, and

1.9 g/t Au at WT

Kuroko massive sulfide. Grab samples contained as muc

and metasedimentary 50 g/t Au, 50 g/t Ag

Devonian metavolcanic as 0.92% Cu, 0.72% Pb, 0.5% Zn,

wide contain 1% Sn

g/t Ag; zones as much as 1 m

Paleozoic marble and g/t Au, 60.4 g/t Ag

marble, and phyllite Ag, 0.14% Cu, 0.03% Zn,

Devonian felsic schist, as 8.2% As, 8.3 g/t Au, 3.9 g/t 63 02

sphalerite, and galena, in metavolcanic rocks and pelitic schist and marble of the

DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Planimetric base from

Geological Society of

Map number. Name

longitude

America DNAG series maps

commodities

SOURCES: Forrest, 1983; Forrest and others, 1984.

1984; Lange and others, 1985; Moore and others, 1986.

Nimiuktuk.

I.F. Ellersieck, written commun., 1985.

Whoopee Creek.

Smucker (Ambler

Arctic (Ambler

Cu, Zn, Pb, Ag

nite - Ambler

Cu, Co, Zn, Ag

district).

1984: Schmidt, 1986

159 54

<u> Table 1.--Significant volcanogenic massive-sulfide and related lode deposits in Alaska</u>

[>, greater than; %, percent]

geologic host unit

Sedimentary exhalative zinc-lead and bedded barite deposits, northwestern Brooks Range

and Pennsylvanian

DESCRIPTION: Disseminated and massive sphalerite, galena, pyrite, marcasite, and sparse

additional sulfide minerals along strike to north and south. Sulfide horizon varies from

possibly a line of vents, occurs within center of deposit, parallel to strike. Host rocks

and Pennsylvanian shale

Mississippian and Pennsylvanian shale, chert, and silica exhalite of the Kuna Formation

50 m thick locally cap deposit. Main occurrences are disseminated sulfide minerals in

organic-rich siliceous shale, coarse-grained sulfide veins, fine-grained fragmental-

textured to indistinctly bedded sulfide minerals, and silica exhalite lenses. Minor

propylitically altered dioritic plug or hydrothermally altered pyroxene andesite flow

Okpikruak Formation structurally underlies deposit. SOURCES: Tailleur, 1970; Plahuta,

hydrathermal alteration: silicification and decarbonatization of shale. Small

Deposit is 1,600 m long and as much as 150 m thick. Occurs near base of formation, locally

subdivided into upper ore-bearing Ikalukrok unit and lower calcareous Kivalina unit (this

study). Latter forms stratigraphic footwall for deposits. Barite-rich lenses as much as

occurs at north end of deposit. Host rocks and deposit extensively structurally imbricated

1978; Booth, 1983; J.T. Plahuta, L.E. Young, J.S. Modene, and D.W. Moore, written commun.,

DESCRIPTION: Massive, nearly pure barite in small isolated hill about 7-10 m high, 40 m

Lower Cretaceous Oknikruak Formation, Altered Mississippian(?) andesite crops out about

180 m from barite. Volume determined by gravity survey and model. SOURCES: Mayfield and

massive sulfide.

chert, tuff

DESCRIPTION: Disseminated and massive sphalerite, galena, pyrite, and barite in

Mississippian shale

Mississippian shale, chert, tuff, and quartz-exhalite of the Kagvik sequence. Locally

disseminations and massive aggregates in quartz-exhalite, and as sparse, remobilized

disseminations in sulfide-quartz veins crosscutting cleavage in shale and chert. Local

kaolinite, montmorillonite, sericite, prehnite, fluorite, actinolite, chlorite, calcite

and quartz. Deposit as much as 1.800 m long and as much as 50 m thick. Host rocks and

deposit extensively faulted and structurally imbricated with many thrust faults dipping

moderately south. SOURCES: Tailleur and others, 1977; Nokleberg and Winkler, 1982; Lang

Unclassified vein and Kipushi copper-lead-zinc deposits, northwestern Brooks Range

DESCRIPTION: Crustified sphalerite and galena in crosscutting quartz veins occurring in

tightly folded strata, indicating replacement origin in Late Jurassic or younger time.

Mississippian sand-

sphalerite, quartz and minor carbonate hosted in tightly folded and faulted sandstone

siltstone, and shale of the Mississippian Kayak Shale. Fracture zone about 6 m long.

1,500 m across tightly folded strata, indicating replacement origin in Late Jurassic or

younger time. SOURCES: Ellersieck and others, 1982; I.F. Ellersieck, written commun.,

DESCRIPTION: Disseminated to massive chalcopyrite, bornite, lesser chalcocite, minor

minerals occurring in veinlets, irregular stringers, or as blebs in brecciated host

tennantite-tetrahedrite, very minor galena, supergene copper carbonates, and iron-oxide

dolomite. Gangue of dolomite, calcite, and quartz anomalously high in Zn and Co. Sulfide

solution breccia. Local remobilization of sulfide minerals into fractures. Local faulted

and brecciated gossan. Host rocks of Ordovician to Devonian dolomite and limestone of the

Baird Group; part of Kelly River allochthon. Host rocks strike north-northeast: dips varv

from gentle to vertical. Local isoclinal minor folds. SOURCES: Degenhart and others, 1978;

Cu, Zn, Pb, barite Ordovician to Devonian tonnes barite; possible 9

Jansons, 1982; Mayfield and others, 1983; I.F. Ellersieck, written commun., 1985; Folger

DESCRIPTION: Chalcopyrite and galena in sinuous quartz-calcite-barite veins, and lense

Ordovician to Devonian dolomite and limestone for minimum distance of 1.6 km. Calcite-

barite veins locally enclose barite lenses. Host rocks part of the Baird Group. SOURCES

Kuroko massive sulfide, Kipushi copper-lead-zinc and metamorphosed sulfide deposits,

DESCRIPTION: Stratiform disseminated fine- to medium-grained pyrite, sphalerite, galena

chalcopyrite, and owyheeite in a quartz-calcite-pyrite matrix. Strike length of 1,000 m

and widths of as much as 60 m. Deposit occurs on limb of recumbent, asymmetric antiform.

schist, quartz-chlorite-calcite phyllite, and porphyroclastic quartz-feldspar-muscovite

alkaline volcanic rocks and impure clastic and calcareous sedimentary rocks. Host rocks

contain abundant south-dipping, tight to isoclinal folds. SOURCES: C.M. Rubin, written

part of the Devonian and Mississippian Ambler sequence. Greenschist-facies metamorphism of

etasedimentary rocks

magnetite, and hematite. Deposit occurs in thick horizon having areal extent of about 900

mainly graphitic pelitic schist and metarhyolite porphyry derived from submarine ash-flow

tuff. Host rocks part of the Devonian and Mississippian Ambler sequence. Gangue of mainly

calcite, dolomite, barite, quartz, and mica. Locally abundant chlorite, phlogopite-talc

barite, and pyrite-calcite-white mica alteration. SOURCES: Wiltse, 1975; Sichermann and

others, 1976; Hitzman and others, 1982; Schmidt, 1983; Jeanine Schmidt, written commun.,

pian metavolcanic and

DESCRIPTION: BT deposit: Disseminated to massive pyrite, chalcopyrite, sphalerite, galena

("button") schist, part of the Ambler sequence. Strike length of 2,000 m; average width of 1.5 m. Layering strikes east-west and dips 50°-70° south. Similar occurrences along same

62 40
152 30

Ruby Creek (Bor- Kipushi Cu-Pb-Zn. 91 million tonnes grading

Devonian dolomite and 1.2% Cu; 4.2 million tonne

metasedimentary rocks Single quartz-barite beds

grading as much as 4% Cu

contained 685-1,029 g/t Ag

and gossan in layers 5-12 cm thick. Sparse tennantite and possible enargite. Gangue of

quartz, muscovite, and barium feldspar in massive sulfide zones. No vertical zonation.

stratigraphic horizon are as long as 10 km in zone to west. Jerri Creek deposit: Mainly

disseminated and sparse massive pyrite, sphalerite, and minor chalcopyrite in layers as

much as 2 cm thick. Hosted in muscovite-quartz schist, actinolite-garnet-quartz schist,

and marble adjacent to metarhyolite, all part of the Devonian and Mississippian Ambler

DESCRIPTION: Stratabound disseminated to massive chalcopyrite, bornite, chalcocite,

sparse carrollite, chalcopyrite, reinerite, galena, pyrrhotite, and marcasite. Large

chalcopyrite, exterior chalcopyrite and pyrite, and peripheral pyrite. Broadly folded.

Greenschist-facies metamorphism. Extensively mineralized hydrothermal dolostone bodies

consisting of biohermal and backreef facies. Locally extensive clasts of hydrothermal

dolostone in breccias, possibly synsedimentary, indicating possible coeval mineralization

and sedimentation. Three major hydrothermal dolomite formation events. Subsequent intense

Hitzman and others, 1982; Hitzman, 1983; M. W. Hitzman, written commun., 1984; Bernstein

Sun (Picnic Creek Kuroko massive sulfide. Average grades of 1-4%

Ambler district). Devonian and Mississip- Pb, 6-12% Zn, 0.5-7%

Cu, Zn, Pb, Ag, Au pian metavolcanic and Cu, 103-343 g/t Ag.

DESCRIPTION: Stratiform, disseminated to massive sphalerite, chalcopyrite, galena, and argentiferous tetrahedrite in gangue pyrite, arsenopyrite, and barite. Deposit occurs in

at least three zoned horizons. Upper horizon is rich in zinc, lead, and silver, middle

mainly in copper, and lower in copper and zinc. Hosted by metarhyolite, muscovite-quartz-

feldspar schist, micaceous calc-schist, marble, and greenstone, all part of the Devonian

moderately southeast. Locally well developed layering in metarhyolite may represent

concordant beds of sulfide minerals in metarhyolite. Small- and large-scale isoclinal

folds in host rocks and sulfide layers. SOURCES: Zdepski, 1980; C.D. Maars, written

original bedding in tuff protolith. Bulk of sulfide minerals in felsic schist; thin

and Mississippian Ambler sequence. Host rocks generally strike northeast-southwest and dip

polymetamorphism and deformation. SOURCES: Runnells, 1969; Sichermann and others, 1976;

pyrite, and local sphalerite occurring in brecciated dolomite and metamorphosed calcareous

sedimentary rocks, part of the Devonian Bornite Marble (Hitzman and others, 1982). Local

masses of dolomite breccia in matrix of dolomite, calcite, or fine-grained pyrite. Pyrite

breccia matrix locally replaced by copper , zinc-, and cobalt-sulfide minerals. Individual

zoned sulfide bodies have interior bornite, chalcocite, and carrollite, middle bornite and

Hosted in Devonian and Mississipian pelitic schist, calc-schist, and metarhyolite

BT. Jerri Creek Kuroko massive sulfide. No data

(Ambler district). Devonian and Mississip-

sequence. Strike length of 20 km. SOURCES: Hitzman, 1978, 1981.

by 1,050 m and in two thinner horizons above main horizon. Sulfides occur in multiple

lenses as much as 15 m thick over vertical interval of 6-80 m. Main horizon hosted in

DESCRIPTION: Stratiform semimassive to massive chalcopyrite and sphalerite and lesser

pyrite, minor pyrrhotite, galena, tetrahedrite, arsenopyrite, and traces of bornite,

phyllite, calc-schist, and marble. Host rocks derived from bimodal calcic and calc-

deposit and host rocks. Host rocks strike west-northwest, dip moderately south, and

Host rocks: a mafic and felsic metavolcanic sequence composed of quartz-muscovite-feldspar

and pods of barite at least 30 m long and 10 m thick. Veins, lenses, and pods crosses

Degenhart and others, 1978; I.F. Ellersieck and J.M. Schmidt, written commun., 1985.

zone about 3 km long occurs along north-northwest-trending fractures and veins. Local

continuous outcrops and associated float along a linear trend having minimum length of

dolomite and limestone Ag

Discontinuous outcrops and associated float along a linear trend about 3,000 m long across

tightly folded and faulted sandstone, siltstone, and shale of the Mississippian Kayak

Shale; part of Brooks Range allochthon. Maximum width of float zone about 30-40 m.

SOURCES: Ellersieck and others, 1982; Mayfield and others, 1983; J.M. Schmidt and

Zn-Ag-Au vein.

and shale

DESCRIPTION: Fracture zones containing siltstone breccia with matrix of galena

extensive hydrothermal alteration of chert and shale with extensive replacement by

Mississippian sand-

stone, siltstone,

and shale

abundant volcanic sandstone and keratophyre. Sulfides occur as disseminations in chert, as

Zn-Pb and (or) Kuroko >2% Pb, 150 g/t Ag

1.5-34% Pb. 1.5-50%

Zn, 35-940 g/t Ag, and

Kipushi Cu-Pb-Zn. Grab samples containing 15.3% 63 45

contained 13.2% Zn,

0.5% Cu, 21% barite

schist; and an interlayered metasedimentary sequence composed of guartz-muscovite-chlorite volcanic graywacke. Metavolcanic and metasedimentary rocks part of Yukon crystalline

written commun., 1984

Bundtzen and Gilbert, 1983.

(Pass Creek)

Stevens, 1971; Seraphim, 1975; Smith, 1981.

Cu, Ag

Ordovician to Devonian Cu, 0.144% Pb, 0.95% Zn, 20 g/t

Cu-Zn-Pb-Ba vein. As much as 0.9 million

dolomite and limestone million tonnes. One vein

Kuroko massive sulfide. Grades of significant massive

pian metavolcanic and Pb, 5-10% Zn, 103-343 g/t

Kuroko massive sulfide. 32 million tonnes gradin

Devonian and Mississip- 4.0% Cu, 5.5% Zn, 1.0% Pb

pian metavolcanic and 51.4 g/t Ag, 0.65 g/t Au

metasedimentary rocks Ag, minor Au

Devonian and Mississip- sulfide minerals average 1-5%

Grab samples containing as much

as 44% Zn, 458 g/t Ag, 4.4 g/t

with many subhorizontal thrust faults. Graywacke of the Jurassic and Lower Cretaceous

tabular to complexly folded. Long and sinuous zone of complex and brecciated textures,

and deposit extensively structurally imbricated with many subhorizontal thrust faults.

barite in Mississippian and Pennsylvanian shale, chert, and quartz-exhalite of Kuna

Formation. Main deposit in zone about 2,000 m long and as much as 500 m downdip;

DESCRIPTION: Disseminated and massive sphalerite, galena, pyrite, and barite in

Tonnage and grade.

production, if known

edimentary exhalative 25 million tonnes grading

Sedimentary exhalative 85 million connes grading

Zn-Pb. Mississippian 17.1% Zn, 5% Pb, 82 g/t Ag

About 1.5 million tonnes

wide, and 60 m long. Stratigraphic contacts not exposed; nearest units are dark shale and zinc-lead deposit. Local lenses of marble interpreted as former limestone mounds that

chert of the Mississippian and Pennsylvanian Kuna Formation and shale and graywacke of the formed near exhalative vents. SOURCES: Herreid, 1965; J.A. Briskey, written commun., 1985.

148 51

Zn-Pb. Mississippian 8.8% Zn, 3.0% Pb, 34 g/t Ag

DeLong Mountains subterrane of Arctic Alaska terrane Endicott Mountains subterrane of Arctic Alaska terrane lammond subterrane of Arctic Alaska terrane North Slope subterrane of Arctic Alaska terrane Angayucham terrane Alexander terrane, undifferentiated Admiralty subterrane of Alexander terrane Craig subterrane of Alexander terrane annette subterrane of Alexander terrane Broad Pass terrane Chulitna terrane Clearwater terrane Crazy Mountains terrane

Kandik River terrane Kagvik terrane Kilbuck terrane

NONACCRETIONARY CONTINENTAL ROCKS AND OCEANIC PLATE

POSTACCRETION COVER DEPOSITS

Sedimentary and volcanic rocks (Upper Cretaceous)

Gravina-Nutzotin belt (Upper Jurassic to mid-Cretaceous)

POSTAMALGAMATION OVERLAP ASSEMBLAGE

ACCRETED TERRANES

[Arranged alphabetically by map symbol]

Coldfoot subterrane of Arctic Alaska terrane

Sedimentary and volcanic rocks (Cenozoic)

Sedimentary and volcanic rocks (Tertiary)

rocks of North America

Pacific plate

North America -- Nonaccretionary Phanerozoic continental

Geology from Jones and

Kuroko massive-sulfide, metamorphosed-sulfide, and bedded-barite deposits,

central southeastern Alaska

DESCRIPTION: Fine-gramed sphalerite, galena, and chalcopyrite as disseminations and in

highly altered and metamorphosed quartz-feldspar porphyry, thin phyllitic siltstone and

mafic extrusive rocks. Schist formed partly from alteration of mafic extrusive rocks and

Sulfide layers and lenses interfoliated with beds of nearly pure barite as much as 20 m

thick. Sedimentary origin indicated by conformable relations between sulfide layers and

DESCRIPTION: Disseminated to massive pyrite, pyrrhotite, sphalerite, and chalcopyrite in

tary and metavolcanic

DESCRIPTION: Sphalerite, galena, chalcopyrite, and tetrahedrite in a pyrite-rich matrix in

massive pods, bands, laminations, and disseminations. Hanging wall composed of chlorite-

composed of black graphitic argillite. "Black ore" forms an extensive blanket deposit and

in laminations in black carbonaceous exhalite and argillite; "white ore" occurs along

sphalerite in laminations, stringers, or disseminations in massive chert, carbonate rocks

massive sulfide deposits. Veins may be brine conduits. Sulfide minerals and host rocks

underlain by serpentinized mafic volcanic flows and tuff. Host rocks part of Alexander

overturned antiform. Workings consist of a 1.300-m exploration add

clastic and volcaniclastic sediments intermixed with mafic flows and tuffs. SOURCES:

Dunbier and others, 1979; Drechsler and Dunbier, 1981; J. Dunbier and D. Sherkenbach

tary rocks

written commun., 1984; H.C. Berg, written commun., 1984.

Peninsula.

others, 1984

and others, 1984.

Zn, Pb, Ag, Cu,

to be a marine exhalative massive-sulfide deposit formed in a late Paleozoic or Triassic

back-arc or wrench fault extensional basin during deposition of arc- or continent-derived

and tuff, and sedimen-

DESCRIPTION: Massive pyrite, sphalerite, galena, and minor chalcopyrite, jamesonite, and

overprinted by intense sericite-pyrite-quartz alteration. SOURCE: Van Nieuwenhuyse, 1984.

Carboniferous marble

DESCRIPTION: Metamorphosed sulfide deposit: Finely disseminated sphalerite and probably

Aggregates, pods, veins, and layers of barite as much as 2 m wide and 60 m long in Uppe

riassic felsic metavolcanic rocks of Alexander belt. SOURCES: Berg and others, 1981;

careous metatuff

DESCRIPTION: Castle Island: Lenses of massive barite interlayered with metamorphosed

pyrite, pyrrhotite, bornite, tetrahedrite, and chalcopyrite. Mined by surface and

sphalerite in Upper Triassic metamorphosed felsic volcanic and volcaniclastic rocks

galena in veins and lenses. Interlayered with Upper Triassic(?) black slate, felsic

metatuff, greenstone, limestone, and mafic intrusive rocks of Alexander belt. Massive

DESCRIPTION: Massive pyrite, pyrrhotite, sphalerite, chalcopyrite, and galena in layer

dikes. About 30 m of underground workings developed in early 1900's. Host rocks in bot

riassic limestone and calcareous sedimentary rocks. Intruded by Tertiary(?) andesite

areas part of Alexander belt. SOURCES: Buddington, 1923; Berg and Grybeck, 1980; Grybeck

and lenses as much as 2 m thick in metamorphosed felsic tuff interlayered with Upper

volcanic rocks

DESCRIPTION: Irregular, elongate, nearly vertical lenses of massive pyrite, chalcopyrite

epidote, garnet, and chlorite. About seven stacked sulfide lenses as much as 70 m long and

6 m thick. Lenses conformable to enclosing felsic to mafic metavolcanic host rocks of the

sphalerite, pyrrhotite, hematite, gahnite, and magnetite. Gangue of quartz, calcite,

pre-Middle Ordovician Wales Group in the Alexander belt. Coarse fragmental textures in

metavolcanic host rocks. Intense chlorite alteration in footwall below sulfide lenses.

DESCRIPTION: Massive chalcopyrite, pyrite, sphalerite, and rare hematite with gangue

Ag, Pb, Zn, Cu

Cu, Au, Ag

Recent development. SOURCE: Herreid, 1964.

Gravina Island.

deposit. SOURCE: Berg and others, 1981.

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quartz, calcite, and epidote occurring in zone as much as 1.2 m thick in layers parallel

quartz veins and diabase dike. Host rocks part of the pre-Middle Ordovician Wales Group in

Alexander belt. Produced about 1,450 tonnes ore between 1898 and 1910. Deposit remobilized

during regional metamorphism. SOURCES: Wright and Wright, 1908; Herreid and others, 1978.

sedimentary rocks

DESCRIPTION: Galena, sphalerite, minor chalcopyrite, and accessory pyrite and siderite in

well-defined fissure veins or reniform pods as much as a few meters wide in a dolomitized

vein breccia cutting obliquely across marble and metasedimentary rocks. Gangue of quartz,

Ordovician Wales Group in Alexander belt. SOURCES: Wright, 1909; Herreid and others, 1978.

DESCRIPTION: Interlayered lenses of barite and dolomite as much as 2 m thick in lower

shipments; no production. SOURCES: Twenhofel and others, 1949; Herreid and others, 1978.

Paleozoic marble of the pre-Middle Ordovician Wales Group in Alexander belt. Local

faulting and folding and andesite dikes intruded along faults. One short adit. Test

volcanic rocks

DESCRIPTION: Lenticular masses and disseminations of chalcopyrite, pyrite, and lesser

pre-Ordovician(?) felsic volcanic or volcaniclastic rocks. Felsic metavolcanic rocks

part of the pre-Middle Ordovician Wales Group in Alexander belt. Workings consist of a

100-m shaft and about 1.6 km of underground workings. Main mining from 1902 to 1909.

volcanic rocks

Driest Point and Kuroko massive sul- No data

nearby area on fide(?). Triassic

DESCRIPTION: Disseminated to massive pyrite and minor sphalerite, galena, and arsenopyrite

in zones as much as a few meters long and 3 m thick. Sulfide minerals also form rinds of

metavolcanic rocks and metagraywacke of Alexander belt. SOURCE: Gehrels and others, 1983.

metavolcanic and meta-

DESCRIPTION: Disseminated to massive pyrrhotite, pyrite, and minor sphalerite in zones as

much as a few meters thick in carbonaceous sedimentary rocks and chert at contact of Upper

sedimentary rocks

Triassic metarhyolite with slate and limestone. Vein deposits containing disseminated

galena, chalcopyrite, and pyrite in veins in shear zones as much as 3 m wide. Gangue of

quartz, calcite, and barite in Triassic metarhyolite. Host rocks part of Alexander belt.

Vein deposits probably formed during Cenozoic remobilization of older massive-sulfide

pillows in metavolcanic rocks. Hosted by Ordovician and Silurian felsic to intermediate

sphalerite, galena, hematite, and magnetite in mainly quartz-sericite schist derived from

nterlayered with intermediate to mafic metavolcanic rocks and lesser slate. Host rocks

Barrier Islands. Kuroko massive sulfide. Grab samples contained as

and shafts. Minor production between 1900 and 1909, Wallrocks part of the pre-Middle

o enclosing metakeratophyre, metaspilite, and quartz-mica schist. Local crosscutting

Lateral gradation between sulfide lenses and enclosing schist. Several hundred meters of

underground workings. Principal mining from 1901 to 1907. SOURCES: Fosse, 1946; Barrie,

sulfide layers as much as 10 cm thick. SOURCES: Berg and Grybeck, 1980; Grybeck and

Triassic calcareous metatuffaceous clastic rocks. Trace amounts of sphalerite, galena

nderwater stripping. Kupreanof Island: Lenses of massive pyrite and lesser galena and

chert, slate, and marble. Lenses as much as 30 m long and 3 m wide. Complexly folded and

faulted. Host rocks in both areas part of Alexander belt. SOURCES: Berg and Grybeck, 1980;

Upper Triassic(?) meta- g/t Au

and Upper Triassic

galena and chalcopyrite in Carboniferous limestone breccia. Bedded barite deposit:

rybeck and others, 1984; H.C. Berg, written commun., 1985.

carbonaceous siltstone, argillite, limestone, and dolomite of Alexander belt. Interlayered

boulangerite in interbedded Upper Triassic(?) felsic to intermediate flows and tuff,

massive-sulfide layers, barite layers, and a siliceous disseminated-pyrite stockwork

zone. Zone beneath massive-sulfide minerals shows chlorite-carbonate alteration

Kuroko massive sulfide. No data

Metamorphosed sulfide. No data

Bedded barite in cal- Produced 680,000 tonnes

Kuroko massive sulfide Massive-sulfide samples con-

metasedimentary rocks sphalerite and 100 g/t Ag

Kuroko massive sulfide. Small tonnage grading 6.1

Kuroko massive sulfide. Grab samples contained as much

Upper Triassic meta- as 5.5 g/t Au and 30 g/t Ag

Kuroko massive sulfide. Produced about 6.4 million

Lower Paleozoic meta- kg Cu, 40,120 g Au, 53,200 g

Metamorphosed sul- Chip sample contained 8.5%

Metamorphosed sulfide. Produced as much as 46,500 g

Bedded barite. Lower Estimated 4,500 tonnes gra-

Kuroko massive sulfide. Produced about 636,000 kg

Lower Paleozoic meta- Cu, 34,200 g Au, 466,500

Lower Paleozoic meta- much as 10% Zn, 0.15% Pb,

30 g/t Ag, and 0.25 g/t Au

g Ag

Paleozoic metasedimen- ding 91% barite

Lower Paleozoic meta- Ag. Grab samples contained

fide(?). Lower Paleozoic 7.3% Zn, 85.8 g/t Ag, 1.7

metavolcanic and meta- g/t Au, 0.06% Pb

Ag from 205,000 tonnes

Au, 106 g/t Ag

ore. Channel samples containe

as much as 5.25% Cu, 6.9 g/t

20-83% Pb. 411 - 1.030 g/t Ag

in metavolcanic and tained as much as 5% galena and

ore grading 90% BaSO4.

or sulfate-rich exhalite. Locally, veins contain bornite, chalcopyrite, and gold below the

belt and apparently overlain structurally several kilometers away by fossiliferous Permian

edges of massive pods and is composed of minor tetrahedrite, pyrite, galena, and

black carbonaceous metasedimentary rocks. Host rocks tightly folded into southeast

is composed of fine-grained pyrite, sphalerite, galena, and silver-rich sulfosalt minerals

and sericite-rich metasedimentary rocks and pyrite-carbonate-chert exhalite. Footwall

partly from quartz-feldspar porphyry. Deposits as much as 9 m thick and 600 m long.

bedding. Host rocks part of Alexander belt; age of host rocks uncertain. SOURCES:

zones as much as 24 m wide and 169 m long in Permian(?) meta-andesite flows and

volcaniclastic rocks of Alexander belt. SOURCE: Brew and others, 1978.

limestone. Sparse disseminated pyrite, magnetite, and tetrahedrite. Main sulfide layers

assive layers and lenses in metamorphosed Paleozic and lower Mesozoic mafic pillow flows

Kuroko massive sulfide. At least 680,000 tonnes gra

Paleozoic and lower ding 45% BaSO<sub>4</sub> and as much as Mesozoic metavolcanic 3% combined Cu and Zn

Kuroko massive sulfide. Samples contain as much as 19%

Permian(?) metavolcanic Zn, 5.2% Cu, 0.5% Ba, 0.16% Pb,

Kuroko massive sulfide. Estimated 3.6 million tonnes

Upper Paleozoic or grading 8% Zn, 2.7% Pb, 0.4% Triassic metasedimen- Cu, 360 g/t Ag, and 3.4 g/t

3.5 g/t Au, and 70 g/t Ag

others (1987), and

Manuscript approved for

MacKevett and others, 1971: Hawley, 1976: Still, 1984

(Big Sore).

Zn, Pb, Cu, Ag,

Besshi and Cyprus massive-sulfide deposits, Prince William Sound district

Besshi massive sul-

fide(?). Upper Creta-

ceous phyllite, gray-

wacke, and greenstone

mineral layering parallels bedding in host sedimentary rocks; both strongly folded. Weak

to unmineralized quartz stockwork in footwall may be feeder system for main ore body. Ore

underground workings with production between 1911 and 1919. Estimated 44,800 tonnes ore

COURCES: Johnson, 1915; Moffit and Fellows, 1950; Rose, 1965; Winkler and others, 1981;

DESCRIPTION: Two major deposits and several smaller ones consisting of a zone of massive

chalcopyrite, cubanite, sphalerite, galena, silver, and gold. Gangue of quartz, sericite

Tertiary Orca Group. Zone as much as 120 m thick and 300 long along strike. Developed and

produced mainly from about 1903 to 1934. SOURCES: Johnson, 1915; Tysdal, 1978; Jansons and 58 04

sulfide lenses and disseminations composed mainly of pyrite and pyrrhotite with minor

and ankerite. Zone adjacent to major fault in graywacke and argillite of the lower

DESCRIPTION: Two major deposits and several smaller deposits of pyrite, pyrrhotite

contacts with host rocks. Deposits occur in pillow basalt of the lower Tertiary Orca

DESCRIPTION: Pyrrhotite and minor chalcopyrite and sphalerite in lens-shaped body in

lite, graywacke

DESCRIPTION: Pyrite, pyrrhotite, chalcopyrite, cubanite, and sphalerite in dissemination

f the lower Tertiary Orca Group. Local diabase dikes. Host rocks folded and sheared

Explored and mined from about 1897 to 1920. A few thousand meters of workings. SOURCES:

lite, graywacke, and

DESCRIPTION: Two deposits of chalcopyrite, pyrrhotite, sphalerite, cubanite, and galena in

Deposits occur in argillite, graywacke, tuff, and pillow basalt of the lower Tertiary Orca

lenticular masses and disseminations. Lenses as much as about 2 m wide and 120 m long.

Group, locally sheared and altered. Explored and mined from about 1904 to about 1918. A

few thousand meters of workings. SOURCES: Capps and Johnson, 1915; Jansons and others,

DESCRIPTION: Chalcopyrite and pyrite, and rare sphalerite and pyrrhotite in broad shear

and sheared graywacke, limestone, and argillite of the lower Tertiary Orca Group.

zones as much as 90 m long. Quartz and calcite gangue. Deposits occur in intensely folded

Developed and mined from 1913 to about 1920. About 750 m of underground workings. SOURCES:

SOUTHEASTERN ALASKA

Metamorphosed sulfide and Besshi massive-sulfide deposits, Coast Mountains Regi

fide. Upper Jurassic

and Lower Cretaceous

91 m wide in Upper Jurassic and Lower Cretaceous greenstone and quartz-calcite-sericite

hydrothermal alteration. A few hundred meters of underground workings completed by 1904.

Mesozoic schist and

cataclastic upper Paleozoic or Mesozoic quartz-rich paragneiss and to a lesser extent in

b). Sulfides locally in veins that may represent remobilized parts of stratabound deposit

schist in the informally named Coast plutonic-metamorphic complex of Brew and Ford (1984a

paragneiss and schist

sphalerite, and lesser bornite, malachite, azurite, and galena in zones as much as 15 m

complex of Brew and Ford (1984a, b), and in part in veins(?) and fault breccia that may

postdate stratabound deposit. SOURCES: MacKevett and Blake. 1963; Brew and Grybeck, 1984;

Upper Paleozoic or

DESCRIPTION: Disseminated to massive pyrrhotite, sphalerite, subordinate magnetite

galena, pyrite, and traces of chalcopyrite. Sulfides occur in several tabular or

enticular zones as much as 1 m thick in upper Paleozoic or Mesozoic calc-silicate,

quartz-feldspar, and hornblende-rich gneiss and schist of the informally named Coast

quartz diorite and numerous younger quartz porphyry sills and dikes. SOURCES:

Buddington, 1923; Gault and others, 1953; Grybeck and others, 1984.

plutonic-metamorphic complex of Brew and Ford (1984a, b). Deposits and host rocks intruded

Ag, Au, Cu, Zn Paleozoic(?) paragneiss containing as much as

DESCRIPTION: Disseminated and veinlike(?) masses of chalcopyrite, pyrite, pyrrhotite, and

sphalerite in zone as much as 25 m wide in Paleozoic(?) paragneiss of the informally named

DESCRIPTION: Sphalerite and galena in discontinuous tabular to lenticular layers as much

as 40 cm thick in fine-grained, dark-silver-gray, upper Paleozoic or Mesozoic micaceous

Several open cuts and 100 m of underground workings. Minor production from 1947 to 1949.

Upper Paleozoic or

Mesozoic metaflysch

DESCRIPTION: Discontinuous lenses and layers of massive pyrite, pyrrhotite, and minor

chalcopyrite and galena. Local disseminated pyrite. Host rocks are light-brown-gray,

upper Paleozoic or Mesozoic muscovite-quartz-calcite schist, minor pelitic schist and

uartz-feldspar schist (possibly metachert). Layers and lenses of massive-sulfide minerals

Metamorphosed sulfide. No data

Metamorphosed sulfide. No data

as much as 1 m thick parallel to compositional layering of schist. Host rocks part of the

nformally named Coast plutonic-metamorphic complex of Brew and Ford (1984a, b). Several

open cuts and about 230 m of underground workings. SOURCES: Robinson and Twenhofel, 1953;

Paleozoic(?) schist

sphalerite in rust-weathering Paleozoic(?) schist of the informally named Coast plutonic-

Paleozoic(?) paragneiss

metamorphic complex of Brew and Ford (1984a, b). About 30 m of underground workings.

DESCRIPTION: Disseminated grains and small masses of pyrite, pyrrhotite, magnetite, and

molybdenite occurring along layering in Paleozoic(?) paragneiss of the informally named Coast plutonic-metamorphic complex of Brew and Ford (1984a, b) intruded by pegmatite and

gneissic granodiorite. Layers range from a few centimeters to 30 m thick. SOURCE: Berg

DESCRIPTION: Massive layers and disseminated pyrite, pyrrhotite, chalcopyrite, and

phyllite of the informally named Coast plutonic-metamorphic complex of Brew and Ford

1984a, b). Originally described as a steeply dipping vein; reinterpreted here as

stratabound deposit partly remobilized during subsequent metamorphism and deformation

zoic flysch

east plutonic-metamorphic complex of Brew and Ford (1984a, b) near foliated granodiorite.

Groundhog Basin. Metamorphosed sulfide. Estimated several hundred

DESCRIPTION: Disseminations and thin, nearly massive layers of chalcopyrite, pyrite,

subordinate sphalerite, and sparse galena. Layers in zones as much as 2 m thick in

DESCRIPTION: Massive lenses and disseminations of pyrrhotite, pyrite, chalcopyrite

wide. Zones occur parallel to layering along crest and flanks of isoclinal fold in

metasedimentary schist and gneiss of the informally named Coast plutonic-metamorphic

schist, part of the Treadwell(?) Slate in the Gravina-Nutzotin belt. Local extensive

Ag, Au, Cu, Pb, Upper Paleozoic or

SOURCES: Brew and Grybeck, 1984; Kimball and others, 1984.

DESCRIPTION: Disseminated pyrite and minor galena and sphalerite in zone 1,600 m long and

Sweetheart Ridge. Metamorphosed sulfide. Estimated 6,600 tonnes gra-

Metamorphosed sulfide. Estimated 24 million tonnes

Paleozoic or Mesozoic grading 0.57% Cu, 0.37% Zn

Metamorphosed sulfide. Grab samples and drill core

Metamorphosed sulfide. Estimated 2,200 tonnes ore

Metamorphosed sulfide. Estimated 91,000 tonnes gra-

about 28% Zn. Produced

ding 7.5% Zn and 1% Cu.

Additional 181,000 tonnes grading 4.5% Zn, 0.75% Cu

several hundred tonnes Zn

Upper Paleozoic or Meso- grading 6-7% Pb, and

and massive-sulfide lenses as much as 70 m thick and 150 m long in argillite and graywacke

long, SOURCES: Johnson, 1915, 1918; Stafansson and Moxham, 1946; Tysdal, 1978.

sheared pillow basalt of the lower Tertiary Orca Group. No production. Lens about 200 m

disseminations. Lenses as much as 9 m thick, average 1.5 m thick. Lenses mainly at sheared

Group. A few hundred meters of underground workings. Minor production. SOURCES: Moffit and

Copper Bullion, Besshi massive sulfide. Estimated 1.0 million tonnes

Lower Tertiary pillow grading 1.25% Cu

Besshi massive sulfide Produced about 7.2 million

Cyprus massive sulfide Produced about 14 500 kg Cu

Besshi massive sul- Produced about 1.89 million

fide(?). Lower Tertiary kg Cu from 19,440 tonnes ore.

graywacke, limestone, Estimated 23,000 tonnes gra-

Lower Tertiary argil- and byproduct Au and Ag

5.96 million g Ag from

million kg Cu, 3,141 g Au

and 165,000 g Ag (Threeman)

ding 7.9 g/t Au, 10.6 g/t Ag, 0.7% Cu

and 10.3-103 g/t Ag,

beneath Sumdum Glacier

thousand tonnes massive

sulfide ore grading 8% Zn

1.5% Pb, and 51.5 g/t Ag;

equal amounts of dissemina

ed sulfide ore grading 2.5%

assuming deposit continue:

274,000 tonnes ore

Lower Tertiary argil- kg Cu, 1,457,000 g Au, and

chalcopyrite, cubanite, sphalerite, and quartz in massive-sulfide lenses and

Latouche, Beatson. Besshi massive sul- Produced more than 84.4 mil-

Cu, Ag, Au, Pb, fide(?). Lower Tertiary lion kg Cu from 4.5 million

argillite and graywacke tonnes ore. Average grade

Cyprus massive sulfide. Produced as much as a few

Lower Tertiary pillow thousand tonnes ore

DESCRIPTION: Disseminated to massive stratiform chalcopyrite, pyrite, pyrrhotite

sphalerite, and minor galena in ore body as much as 7 m thick and 300 m long. Sulfide

bodies in phyllite and metagraywacke of the Upper Cretaceous Valdez Group. Extensive

mined. Earlier workers interpreted deposit as epigenetic replacement in shear zones.

ansons and others, 1984; S.W. Nelson, written commun., 1986.

others, 1984.

Knight Island,

Fellows, 1950; Tysdal, 1978; Jansons and others, 1984

Capps and Johnson, 1915; Jansons and others, 1984.

Standard Copper.

Cu, Au, Ag, Zn

Fidalgo-Alaska,

Au, Pb, Zn

Ag, Cu, Zr

Kimball and others, 1984

SOURCES: Berg and others, 1977

Ag, Pb, Zn

Cu, Zn

(Roe Point).

SOURCE: Wright and Wright, 1908.

Cu, Mo

Berg and others, 1978; H.C. Berg, written commun., 1984.

131 21

130 31

134 43

SOURCE: Spencer, 1906.

Capps and Johnson, 1915; Jansons and others, 1984.

Chugach Mountains

Average grades of about 3.2%

Cu, 13.7 g/t Ag, 2.1 g/t Au.

Produced 1.54 million kg Cu,

471,000 g Ag, 79,000 g Au.

about 1.7% Cu, 9.3 g/t Ag

grading 1.6% Cu remain

Estimated 56,200 tonnes ore

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EDITOR'S NOTE

Livengood terrane

McKinley terrane

Maclaren terrane

Minook terrane

Nenana terrane

Nyack terrane

Nixon Fork terrane

Porcupine terrane

Peninsular terrane

Pingston terrane

Ruby terrane

Seward terrane

Saint Elias terrane

Sheenjek terrane

Susitna terrane

Seventymile terrane

Tracy Arm terrane

Togiak terrane

Tikchik terrane

Tozitna terrane

West Fork terrane

Wrangellia terrane

Wickersham terrane

Yakutat terrane

Yukon-Tanana terrane

Southern Taku terrane

Northern Taku terrane

Central Taku terrane

Woodchopper Canyon terrane

White Mountains terrane

Prince William terrane

Minchumina terrane

This map is one of several planned or published products of a study of the distribution and setting of volcanogenic massivesulfide occurrences in the Western United States. The term "volcanogenic massive-sulfides" refers to occurrence types that are inferred to be associated with the development of ancient island arc or rift systems in a mainly subaqueous environment Most massive-sulfide occurrences shown on this map were probably deposited in ancient island arc and rift environments and are considered to be either "proximal" or "distal" with respect to their emplacement near centers of submarine volcanic activity.

INTRODUCTION AND PURPOSE

This map and accompanying text is a compilation of the significant volcanogenic massive-sulfide and related lode deposits of Alaska as of early 1987. The map and accompanying text are parts of (1) a U.S. Geological Survey Bulletin entitled "Significant Metalliferous Lode Deposits and Placer Districts of Alaska" by Nokleberg and others (1987); and (2) a chapter of the forthcoming Alaskan volume of the Decade of North American Geology series, entitled "Metallogeny and Major Mineral Deposits of Alaska" by Nokleberg and others (1988). Both of the source articles contain previously unpublished data contributed by 54 mineral deposit and regional geologists in private industry, universities, the U.S. Geological Survey, the Alaska Division of Geological and Geophysical Surveys, the U.S. Bureau of Mines, and the authors. These data were collected principally in the last decade during a period of intense exploration for lode deposits by private industry, and, at the same time, during a period of intense mineral deposit and mineral resource assessment studies by mineral deposits geologists in universities, the U.S. Geological Survey, the U.S. Bureau of Mines, and the Alaska Division of Geological and Geophysical Surveys. Published studies of mineral deposits, cited below and in table 1, were also used to complete the summaries of the significant volcanogenic massive-sulfide and related deposits in Alaska. This report consists of three parts. The first part is a map that shows the locations of the significant volcanogenic massivesulfide and associated lode deposits in Alaska. The second part is this text, which provides introductory material, summarizes the classification of types of volcanogenic massive-sulfide and related lode deposits, summarizes the regional geologic setting of the significant deposits, and lists pertinent references. The third part is table 1, which provides new and timely detailed summaries of the significant volcanogenic massive-sulfide and related lode deposits in Alaska as of early 1987. In this and related reports, the term "significant deposits" is defined as all metalliferous mines, prospects, deposits, or occurrences that we judge to be important, on the basis of size, geological

importance, or scientific interest. For each significant deposit, table 1 lists the geographic coordinates, common names, major metals or commodities, a mineral deposit type, the host-rock geology, data on tonnage, grade, and production, if known, and sources of information. One result of the geologic mapping and associated geologic studies of Alaska in the last decade is the recognition of numerous fault-bounded assemblages of rocks designated as tectonostratigraphic terranes. Proponents of this concept suggest that most of Alaska consists of a collage of such terranes (Jones and others, 1987; Monger and Berg, 1987). Maps from these authors are used as the geologic base for the map in this report. In the text, the rock units in each tectonostratigraphic terrane are used to describe the geologic setting of the significant volcanogenic

massive-sulfide and related lode deposits in Alaska.

CLASSIFICATION OF TYPES OF VOLCANOGENIC MASSIVE-SULFIDE AND RELATED LODE DEPOSITS The significant volcanogenic massive-sulfide and related lode deposits described in this report are classified into seven distinct models or deposit types. These deposit types, summarized below. are Kuroko massive sulfide, Besshi massive sulfide, Cyprus of mainly pyrite and marcasite and lesser sphalerite, massive sulfide, sedimentary exhalative zinc-lead, Kipushi copperlead-zinc (carbonate-hosted copper), metamorphosed massive sulfide, and bedded barite. As a group, these deposit types are generally interpreted by most investigators to have been deposited in ancient submarine island-arc, submerged continental-margin arc, or rift systems. This classification of mineral deposits is mainly derived from the mineral deposit models of specialists as compiled in Cox and Singer (1986), and to a lesser degree from earlier studies of Erickson (1982) and Cox (1983a, b). For a few lode deposits, lack of data precludes classification into a specific mineral deposit type. For these deposits, a brief description of the deposit is enclosed in parentheses under the type heading in table 1. The mineral deposit models used in this report and in Cox and Singer (1986) consist of both descriptive and genetic information that is systematically arranged to describe the essential properties of a class of mineral deposits. Some models are descriptive (empirical), in which case the various attributes are recognized as essential, even though their relationships are unknown. For

models, the reader is referred to the discussion by Cox and Singer Kuroko Massive-Sulfide Deposit

additional information on the methodology of mineral deposit

(D.A. Singer in Cox and Singer, 1986) This deposit type consists of volcanogenic, stratiform massive to disseminated sulfide minerals in felsic to intermediate marine volcanic and pyroclastic rocks and interbedded sedimentary rocks, and a subjacent stringer (stockwork) system. The volcanic rocks are mainly rhyolite and dacite, but contain subordinate basalt and andesite. The depositional environment is mainly hot springs related to marine volcanism in island-arc or extensional regimes. The deposit minerals include pyrite, chalcopyrite, sphalerite, and lesser galena, tetrahedrite, tennantite, gold, and magnetite. Alteration products include zeolite minerals montmorillonite, silica in various forms, chlorite, and sericite. Notable examples of Kuroko massive-sulfide deposits in Alaska are the Arctic, Smucker, and Sun deposits in the Brooks Range, the WTF, Red Mountain deposit, and deposits in the Delta district in east-central Alaska, and the Greens Creek, Glacier Creek, Khayyam,

and Orange Point deposits in southeastern Alaska. Besshi Massive-Sulfide Deposit (D.P. Cox in Cox and Singer, 1986)

This deposit type consists of thin, sheet-like bodies of massive to well-laminated pyrite, pyrrhotite, and chalcopyrite and less abundant sulfide minerals, within thinly laminated clastic sedimentary rocks and mafic tuff. The rock types are mainly marine clastic sedimentary rocks, lesser amounts of basalt and andesite tuff and breccia, and local black shale and red chert. The depositional environment is uncertain, but may be submarine hot springs related to submarine basaltic volcanism Associated minerals include sphalerite and lesser magnetite, galena, bornite, and tetrahedrite. Gangue includes quartz, carbonate minerals, albite, white mica, and chlorite. Alteration is difficult to recognize in some places because of metamorphism. Notable examples of Besshi massive-sulfide deposits in Alaska are the Prince William Sound region of southern Alaska.

This deposit type consists of massive sulfide minerals in pillow basalt. The depositional environment consists of submarine hot springs along an axial graben in oceanic or backarc spreading ridges or hot springs related to submarine volcanoes in seamounts The deposit minerals consist mainly of pyrite, chalcopyrite, sphalerite, and lesser marcasite and pyrrhotite. The sulfide minerals are in pillow basalt that is associated with tectonized ophiolite-related dunite, harzburgite, gabbro, sheeted diabase dikes, and fine-grained sedimentary rocks, all part of an sphalerite. The sulfide minerals are locally brecciated and re-

ophiolite assemblage. Beneath the massive-sulfide ore in places is stringer or stockwork pyrite, pyrrhotite, minor chalcopyrite, and cemented. Alteration in the stringer zone consists of abundant quartz, chalcedony, chlorite, and minor illite and calcite. Some deposits are overlain by iron-rich and manganese-poor ochre. Notable examples of Cyprus massive-sulfide deposits in Alaska are the Knight Island and Threeman mines and the Copper Bullion deposit, all in coastal southern Alaska

disseminated sulfide minerals in sheet-like or lens-like tabula bodies that are interbedded with euxinic marine sedimentary rocks including dark shale, siltstone, limestone, chert, and sandstone. The depositional environment consists mainly of marine epicratonic embayments and intracratonic basins, and associated smaller, local restricted basins. The deposit minerals include pyrite, pyrrhotite, sphalerite, galena, barite, and chalcopyrite. Extensive alteration minerals may be present, including stockwork and disseminated sulfide minerals (previously mentioned), silica in various forms, albite, and chlorite. Notable examples of sedimentary exhalative zinc-lead deposits in Alaska are the Lik and Red Dog Creek deposits in the northwestern Brooks Range.

minerals hosted mainly by dolomitic breccia. The depositional environment consists mainly of strong fluid flow along faults or karst(?)-breccia zones. Generally no rocks of unequivocal igneous origin are related to the deposit. The deposit minerals include pyrite, bornite, chalcocite, chalcopyrite, carrollite, sphalerite, siderite. and silica in various forms. all as alteration products, may be present. Notable examples of carbonate-hosted copper deposits in Alaska are the Ruby Creek and Omar deposits in the Brooks Range. In parts of Alaska, Kipushi copper-lead-zinc deposits such as that at Ruby Creek are generally associated with

in the Ambler district.

Metamorphosed Sulfide Deposit (Nokleberg and others, 1987) disseminated sulfide minerals hosted by moderately to highly metamorphosed and deformed metavolcanic or metasedimentary rocks. Metamorphism and deformation have obscured protoliths of host rocks and deposits so as to preclude classification into more specific deposit types. The interpreted host rocks for these deposits are mainly felsic to mafic metavolcanic rocks and metasedimentary or metavolcanic schist and gneiss. The deposit minerals include chalcopyrite, sphalerite, galena, gold, and bornite, in some cases with pyrite, magnetite, and hematite. Alteration is usually difficult to recognize because of metamorphism. These deposits are mainly in regional metamorphic rocks in southeastern Alaska, either in the informally named Coast

Bedded-Barite Deposit (G.J. Orris in Cox and Singer, 1986)

interbedded with marine, chert-rich and calcareous sedimentary rocks, mainly dark chert, shale, mudstone, and dolomite. The depositional environment consists mainly of epicratonic marine deposits. Alteration consists of secondary barite veining and deposit in the northwestern Brooks Range and the Castle Island mine in southeastern Alaska.

chemical symbols for elements, for example, Au, gold; Cu, copper; Fe, iron; U, uranium

mm, cm, m, km: millimeter, centimeter, meter, kilometer

table 1). The southern flank of the central Brooks Range contains Brew, D.A., Ovenshine, A.T., Karl, S.M., and Hunt, S.J., 1984 an extensive suite of major Kuroko massive-sulfide deposits and one major carbonate-hosted Kipushi copper-lead-zinc deposit. Significant lode mineral deposits in the Brooks Range and Seward Peninsula are further summarized by Einaudi and Hitzman (1986).

sparse intermediate to silicic volcanic rocks, mainly keratophyre, named the "Kuna Formation" (Mull and others, 1982). The Kuna Formation forms the basal unit of the Kagvik sequence (Churkin and others, 1979) and the Kagvik terrane (Jones and others, 1987) This unit, as well as younger late Paleozoic and early Mesozoic chert and shale, are interpreted either as a deep-water, allochthonous oceanic assemblage (Churkin and others, 1979; Nokleberg and Winkler, 1982; Lange and others, 1985) or as an

The northwestern Brooks Range contains a belt of large

sedimentary exhalative zinc-lead and bedded-barite deposits that

extends along strike for more than 200 km (map, table 1). The

estimated 25 million tonnes of ore (Forrest, 1983; Forrest and

others, 1984), and Red Dog Creek, which contains an estimated 85

million tonnes of ore and ranks within the top 20 percent, based

on size, of known deposits of this type (Moore and others, 1986)

(table 1) A somewhat similar deposit at Drenchwater Creek is in

additional deposits in the northwestern Brooks Range (Nokleberg

The sedimentary exhalative zinc-lead and bedded-barite

deposits in the northwestern Brooks Range are in a tectonically

Pennsylvanian chert, shale, limestone turbidite, minor tuff, and

disrupted and strongly folded assemblage of Mississippian and

barite (table 1). Substantial potential exists for finding

and Winkler, 1982; Lange and others, 1985).

Both deposits have high concentrations of zinc, lead, and silver

both sedimentary and volcaniclastic rocks (table 1). The Nimiuktuk

bedded-barite deposit contains an estimated 1.5 million tonnes of

largest zinc-lead-silver deposits are Lik, which contains an

assemblage deposited in an intracratonic basin (Mull and others, 1982: Mayfield and others, 1983). The sedimentary exhalative zinclead and bedded-barite deposits are interpreted to have formed either in an incipient submarine continental-margin arc or in the early stages of a long-lived, sediment-starved, epicontinental

minor quartz, and minor carbonate gangue in veins and fractures that cut the Mississippian Kayak Shale of the Endicott Group at the Story Creek and Whoopee Creek deposits and in dolomite and limestone of the Baird Group at Frost. The veins and fractures are in linear zones from 1.5 to 3 km long that cross tightly folded strata; an epigenetic origin is indicated (I.F. Ellersieck and J.M. Schmidt, written commun., 1985). No tonnage and grade data are available. Insufficient data preclude assignment of some of these deposits to a specific mineral deposit type. The Omar

and other sulfide minerals in veinlets, stringers, and blebs in brecciated Ordovician to Devonian dolomite and limestone of the Baird Group (Folger and Schmidt, 1986), and it is classified as a Kipushi copper-lead-zinc deposit (table 1). The Endicott Group, which hosts the Story Creek and Whoopee Creek deposits, forms part and one Kipushi copper-lead-zinc deposit is aligned along an east-

significance of carrolite and the copper-germanium sulfide renierite in the Ruby Creek deposit as a link to the dolomitehosted deposits at Kipushi and Zaire (Cox and Singer, 1986).

in the northeastern part of the peninsula at Hannum Creek (map, table 1). The deposit consists of blebs, stringers, massive enses, and disseminations of galena, pyrite, sphalerite, and barite parallel to layering in Paleozoic quartz-mica schist and marble that are part of the Nome Group (mixed unit of Till, 1984). The deposit is interpreted as a metamorphosed laminated exhalite, possibly a former sedimentary exhalative zinc-lead deposit (J.A. EAST-CENTRAL ALASKA - NORTHERN ALASKA RANGE

East-central Alaska contains an extensive suite of Kuroko massive-sulfide deposits in the northern Alaska Range: Liberty Bell, Sheep Creek, Anderson Mountain, WTF, Red Mountain, Miyaoka Hayes Glacier, McGinnis Glacier, and deposits in the Delta district (table 1). The Kuroko massive-sulfide deposits extend for 250 km along strike on the northern flank of the Alaska Range (map), and constitute one of the longer belts of massive-sulfide deposits in Alaska. Substantial base and precious metals are resent in these deposits (Nokleberg and others, 1987). The Liberty Bell deposit contains an estimated 91,000 tonnes grading 10 percent As, 2 percent Cu, and 34 g/t Au. The WTF and Red Mountain deposits contain an estimated 1.10 million tonnes grading 0.15 percent Cu, 2.5 percent Pb, 7.9 percent Zn, 270 g/t Ag, and 1.9 g/t Au. The largest deposit in the Delta district contains an estimated 18 million tonnes grading 0.3-0.7 percent Cu, 1-3 percent Pb, 3-6 percent Zn, 34-100 g/t Ag, and 1-3.4 g/t Au. Deposits in this belt have been discovered mainly within the last 10 years. Potential exists for the discovery of additional The Kuroko massive-sulfide deposits in the northern Alaska Range are in Devonian or older polymetamorphosed, polydeformed, submarine metavolcanic rocks, pelitic schist, calc-schist, and

marble. Very few or no gneissic granitic rocks occur (Aleinikoff and Nokleberg, 1985; Nokleberg and Aleinikoff, 1985; Nokleberg and (Nokleberg and Aleinikoff, 1985). Metamorphic grade ranges from amphibolite facies at depth to greenschist facies at higher levels Locally abundant Cretaceous(?) gabbro to diorite dikes and sills crosscut schistosity and foliation in the sequence. Structurally overlying these older rocks are metasedimentary and metavolcanic rocks of the Precambrian or early Paleozoic Keevy Peak Formation massive-sulfide deposits are interpreted as having formed during

The geology of southeastern Alaska is varied and complex. In plutonic-metamorphic complex of Brew and Ford (1984a, b), which is the Sitka Graywacke and similar unnamed rocks, part of the Chugach variety of volcanogenic massive-sulfide deposits (Berg and others,

Metamorphosed sulfide deposits present in the Coast Mountains preclude classification into a more specific deposit type. Some of the deposits may be metamorphosed Kuroko massive-sulfide deposits. terrane (map). The Red River deposit is in the central part of the Substantial amounts of copper, lead, zinc, and silver are present 1.5 percent Pb, and 51.5 g/t Ag. The Moth Bay deposit contains an and an additional estimated 181,000 tonnes grading 4.5 percent Zn

deposits. These deposits in central southeastern Alaska are hosted

classify these two deposits. Bedded-barite deposits in central southeastern Alaska are Castle Island and Lime Point. The Castle Island deposit produced 680,000 tonnes of ore grading 90 percent

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Inyo F. Ellersieck - U.S. Geological Survey Curtis J. Freeman - Onyx Exploration, Incorporated, Fairbanks, D.R. Gaard - Resource Associates of Alaska, Incorporated, Fairbanks, Alaska Murray W. Hitzman - Chevron Resources Company, San Francisco, Ian M. Lange - Department of Geology, University of Montana, Missoula, Mont. Christopher D. Maars - Anaconda Minerals Company, Anchorage, J.S. Modene - Cominco Alaska, Incorporated, Anchorage, Alaska David W. Moore - Cominco, Incorporated, Anchorage, Alaska Clint R. Nauman - Research Associates of Alaska, Incorporated, Fairbanks, Alaska Steven R. Newkirk - Research Associates of Alaska, Incorporated, Fairbanks, Alaska Steven H. Nelson, U.S. Geological Survey Harold Noyes, Doyon, Limited, Fairbanks, Alaska Joseph T. Plahuta - Cominco Alaska, Incorporated, Anchorage,

John Dunbier - Noranda Exploration, Incorporated, Anchorage,

Surveys, Fairbanks, Alaska

Charles M. Rubin - Anaconda Minerals Company, Denver, Colo. D.A. Scherkenbach - Noranda Exploration, Incorporated, Anchorage Jeanine M. Schmidt - U.S. Geological Survey P R. Smith - U.S. Borax and Chemical Corporation, Spokane, Wash. J.E. Stephens - U.S. Borax and Chemical Corporation, Spokane, Loren E. Young - Cominco Alaska, Incorporated, Anchorage, Alaska

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